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By Kurtulmuş, Özar and Warner

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Research or teaching oriented? Game theory models for the strategic decision-making process of universities with the external environment held neutral

Bekir Emre Kurtulmuş[a], Cigdem Özar[a], and Bernadette Warner *[b]

[b] *College of Business Administration, Al Falah University, Dubai, UAE*
[a] *Economics and Administrative Sciences, Istanbul Aydin University, Turkey*

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A key choice that must be made by a new or young university is that of the selected balance between research and teaching on the continuum of options. We approach this choice from a strategic decision-making perspective, by implementing a game theory approach to analyse the selection process. Three main groups of players were identified: faculty members or academicians, university management members, and board of trustees' members. The decisions of these players were then analysed by the use of a Fuzzy TOPSIS method. Our findings show how, in choosing from the options continuum, the players arrived at equilibria points that best satisfied their collective perspectives as to the required balance, for the purpose of achieving optimal benefit.

keywords: Game Theory, Strategic-Decision Making Process, Fuzzy TOPSIS Method, Research/Teaching Continuum.

1 Introduction

The creation and maintenance of effective strategies constitute one of the most important steps leading to organizational success (Garbuio et al., 2015). Scholars have sought to

*Corresponding author: warner@afu.ac.ae

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understand how organizations make decisions within complex environments. A successful decision-making process within organizations depends on a range of criteria, such as relevant information, the identification of constraints, the application of effective management techniques (Elbanna and Child, 2007), including managerial control (Elbanna, 2016); organizational cultural values (Hatch, 1993); management intuition (Miller and Ireland, 2005); and internal organizational politics (Pfeffer, 1992; Wilson 2003; Ferris et al. 2007; Hung et al. 2012). It is well documented that the extent to which decision making processes are truly strategic impacts process efficiency and decision effectiveness (Rodrigues and Hickson, 1995; Elbanna and Child, 2007). Faculty members may be required to "publish or perish"; to ensure the success of their students, as reflected in relatively high retention and graduation rates; to engage in research-driven or informed teaching; or to emphasize the achievement of expected course and program outcomes, The decision as to the balance to strike between research and teaching orientations may be difficult for many new or young universities, where the business environment offers sufficient degrees of freedom. Any balance struck implies distinctive advantages and disadvantages, with significant potential impact upon institutional survival. Multiple factors must be considered. Once an initial choice is made, some universities may suffer from institutional inertia, or primarily focus on reputation and resources to remain afloat (Rousseau, 2012). Arguably, one of the most important criteria consists of the assurance of stakeholder satisfaction. This study approaches the "research or teaching orientation" decision from a game theory perspective, and identifies outcomes from each choice made. Young universities are chosen for the purpose of this study. Three main players are identified; academicians, managerial staff Dean, Vice Deans, Vice Rectors and Rectors or Presidents, and Boards of Trustees. Under time pressure, the three players, who may have different priorities and agendas, must attempt to decide upon the course of action most beneficial for a young university. This study will also shed light upon the decision that should be made by such universities, in cases where business environment and resource constraints allow sufficient decision-making flexibility. It provides an understanding of how, under such conditions, the best possible decisions can be identified, so as to ensure long-term survival. In order to conduct the required analysis a fuzzy topsis methodology is implemented. Such a technique for order preference by similarity to ideal situation (topsis) can help in objective and systematic evaluation of multiple criteria. In the topsis approach, an alternative that is nearest to the fuzzy positive ideal solution and farthest from the fuzzy negative ideal solution is chosen as optimal. The former is composed of the best performance values for each alternative whereas the latter consists of the worst performance values. By way of a basic definition, a fuzzy set a in a universe of discourse X is characterized by a membership function $\mu \sim a(x)$ that maps each element x in X to a real number in the interval $[0, 1]$. The function value $\mu \sim a(x)$ is termed the grade of membership of x in $\sim a$. The nearer the value of $\mu \sim a(x)$ to unity, the higher the grade of membership of x in $\sim a$ (Jiang et al., 2008).

2 Theoretical Background

2.1 Strategic Decision Making Process

Strategic decision making processes can be described as "committing substantial resources setting precedents and creating waves of lesser decisions" (Mintzberg et al., 1976). There are three main perspectives on strategic decision-making process: rationality, bounded rationality and garbage can model (Schalk et al., 2013). Power, politics and cognitive factors play an important role (Eisenhardt and Zbaracki, 1992). Successful strategies increasingly rely on structure (Osborn, 1998). One of the biggest challenges for managers is to cope with environmental uncertainty, and successful decision-making process helps firms to reduce uncertainty (Kaplan and Orlikowski, 2013). In addition, high performance within organisations rely on decision makers "ability to reduce tension between flexibility and efficiency"(Tushman and O'Reilly, 1996). Senior management teams make strategic decisions that impact on organizational performance (Amason, 1996). Such decisions require the commitment of substantial resources and contribute to either survival or failure. It is difficult to define or assess the outcomes of strategic decisions as they involve different trade-offs and risks. Organizational decisions may be split into the broad categories of content and process. The first category focuses on strategy content such as investment, portfolio management and investment decisions. The second set deals with issues of how strategic decisions are made and factors influencing them (Elbanna, 2006). The effectiveness of strategic decision-making processes depends on multiple criteria. One of the key ingredients of effective decision-making is to be evidence-based. Every decision-making process should primarily rely on either existing qualitative or quantitative data (Pfeffer and Sutton, 2006). In addition, it is apparent that evidence based management practices are quite effective when business schools are designed (Rousseau, 2012). Strategic-decision making choices must also consider possible outcomes (Garbuio et al., 2015).

On of the other important factors that impact strategic decision-making process effectiveness consists of environmental circumstances (McKelvie et al., 2011). For instance, market uncertainty implies unpredictable and unstable conditions. In such a context neither outcomes nor probabilities can be foreseen. These issues are particularly important in the early stage of strategic decision making process and more relevant to technology-based ventures (Reymen et al., 2015). In response to market uncertainty, decision-makers may adopt either planning or adaptive approaches. In the first case, they focus upon detailed internal and external environmental analysis for planning purposes, whereas in the latter situation, incremental actions may be implemented as a means of responding to uncertain and unknown situations, without formal planning (Wiltbank et al., 2006).

2.2 Game Theory

Game theory is a mathematical system that is implemented to understand and analyze how human being behave in strategically. Von Neumann and Morgenstern outlined the main features of the game theory in 1944. A few years later the mathematician John Nash proposed a solution to the problem that as to how rational player would behave, leading to Nash equilibrium. He contented that all players would adjust their response according to those of players until none of could benefit from changing. In final step all players would choose their strategies that are best responded to others' strategies (Camerer, 2003). Game theory becomes relevant when there is interdependence among players. It means one player's choice dependent on the choice that others made (Johnson et al., 2013). One of the base assumptions in the game is that the players would eventually meet at an equilibrium point if they behave rationally. However, in many experiments it is seen that they are not in an equilibrium point. This is because a player may wrongly perceived other players beliefs. Therefore, cannot precisely predict the outcomes (Camerer et al., 2004). Furthermore, in a minimal social situation game theory can be one of the best tools to analyse strategic choices and outcomes (Colman, 2013). Nonetheless, eventually, the game theory is about group thinking or more precisely how best to predict what other people will do in a specific given situation (Camerer et al., 2004).

3 Conclusion

The results showed a significant relationship between organizational culture, Accreditation cost and strategic intention. Based on fuzzy logic simulation, private higher-education institution should move from hesitation due to costly accreditation requirements to realizing the benefits of having implemented risk management towards adopting international activities such as international accreditation. In conclusion, based on the research problem addressed, the findings suggest that Jordanian private universities need to make more reliable and implementable strategies by taking into consideration environmental conditions. More specifically, universities should make some changes in term of decision making, especially in respect to international accreditation. This could be accomplished by allowing subordinates to contribute to decision making and allowing them to put forth their observations regarding environmental conditions. Practically, private university leaders should involve subordinates in decision-making, and leaders in private universities should encourage subordinates to act upon new changes.

3.1 Fuzzy TOPSIS

Fuzzy TOPSIS is a technique for order preference by similarity to ideal solution (Wu et al., 2007). Simply stated, it is in very core; the furthest possible distance from negative solution and the closest solution to a positive outcome. In that, fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) are calculated. It is a multi-criteria solution that helps to identify the most appropriate resolution from a set of options (Aplak and Sogut, 2013). In fuzzy TOPSIS methodology weights of all criteria are assessed with linguistic terms that are represented by fuzzy numbers. The values of each criterion converted into dimensionless indices. By doing so, the compatibility between the values of objective criteria and the linguistic ratings of subjective criteria is ensured (Chu and Lin, 2003). This is proposed by Hsu and Chen (1997). Objective attributes have numerical values and subjective attributes have qualitative descriptions

(Chu and Lin, 2003). A linguistic value is identified as a variable and they are transformed in to a questionnaire (Aplak and Sogut, 2013). It is claimed that in appropriately set games, across a majority of scenarios, fuzzy agents win more often than normally expected (Oderanti and De Wilde, 2010).

3.2 Research or Teaching Oriented Universities

There has been much discussion as to whether, when the immediate business environment is held constant or neutral, a university should be primarily focused on teaching or research, or should simply emphasize both simultaneously (Cummings and Shin, 2014). A research orientation generally contributes to institutional prestige (Armstrong and Sperry, 1994). In his well-noted writings Boyer (1991), (1996) contended that more attention should be given to scholarship of dissemination and integration and also that universities should engage more robustly with real life problem solving applied research.

4 Methodology

Behavioral models of the games are meant to be very general. Developed models can be applied to many different games with little adjustment (Camerer, 2003). For the purpose of the study three different players from a newly founded-less than ten years old- university is identified. Academics, management and board of trustees. Those three players are on the constant competition for the limited resources and they may have different priorities. Three possible outcomes are also discussed. Being teaching, research or teaching/research oriented. In order to identify evaluation criteria. The Times best universities criteria are implemented. This tool uses one of the most trustable criteria available as it has been developed for participation of different participant. It also relies on statistical analysis which make it more robust. We identified 13 different criteria from The Times best universities ranking tool. The players are asked which one of those criteria are more relevant and important in different circumstances. The criteria are taken from The Times the best universities list and implemented for the purpose of this research are:

- Research Income from Industry
- Ratio of International to Domestic Staff
- Ratio of International to Domestic Students
- Reputational survey (teaching)
- PhDs awards per academic
- Undergraduate admitted per academic
- Income per academic
- PhDs/undergraduate degrees awarded

- Reputational survey (research)
- Research income (scaled)
- Papers per research and academic staff
- Public research income/ total research income
- Citation impact (normalized average citation per paper)

In order to follow the above criteria Chen and Hwang's (1992) algorithm of group multi-criteria decision-making is implemented by the following steps.

Step 1 : Identify the evaluation criteria

Step 2 : Choose appropriate linguistic variables

Step 3 : Aggregate the weight of the criteria to obtain the aggregated fuzzy weight of the criterion C_j and pool the decision makers' opinions to obtain the aggregated fuzzy rating X_{ij} of alternative A_i under criterion C_j

Step 4 : Construct the fuzzy decision matrix

Step 5 : Construct the normalized fuzzy decision matrix

Step 6 : Construct the weighted normalized fuzzy decision matrix

Step 7 : Determine the FPIS (Fuzzy Positive Ideal Solution) and FNIS (Fuzzy Negative deal Solution)

Step 8 : Compute the distance of each alternative from FPIS and FNIS (using Euclidean distance function)

Step 9 : Compute the closeness coefficient of each alternative

Step 10 : Determine the ranking order of all of the alternatives according to the closeness coefficient.

Assume that the decision group has K members (nine in our study). If the fuzzy rating and importance weight of the k^{th} decision maker about the i^{th} alternative on the j^{th} criteria (thirteen criteria in our study) are denoted by $\tilde{X}_{ij}^k = (a_{ij}^k, b_{ij}^k, c_{ij}^k)$ and $\tilde{W}_{ij}^k = (W_{j1}^k, W_{j2}^k, W_{j3}^k)$ where $i = 1, 2, ..., m$ and $j = 1, 2, ..., n$ then the fuzzy ratings $\tilde{X}_{ij}$ of alternatives (i) with respect to each criteria (j) are given by $\tilde{X}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ such that a_{ij} is the minimum, b_{ij} is the weighted average and c_{ij} is the maximum of their values, as in equation (1).

$$a_{ij} = min_k(a_{ij}^k); b_{ij} = \frac{1}{K}\sum_{k=1}^{K} b_{ij}^k acij; c_{ij} = max_k(c_{ij}^k) \tag{1}$$

The aggregated fuzzy weights $\tilde{W}_{ij}$ of each criterion are calculated as: $(W^k_{j1}, W^k_{j2}, W^k_{j3})$ such that W^k_{j1} is the minimum,W^k_{j2} is the weighted average and W^k_{j3} is the maximum of their values in equation (2).

$$w_{j1} = min_k(w_{kj1}); w_{j2} = \frac{1}{K}\sum_{k=1}^{K} w_{kj2}; w_{j3} = max_k(w_{kj3}) \tag{2}$$

A fuzzy multicriteria Group Decision Making (GDM) problem can be expressed in following matrix format, as in equations (3) and (4).

$$D = \begin{array}{ccccc} ... & C_1 & C_2 & ... & C_n \\ A_1 & \tilde{x}_{11} & \tilde{x}_{12} & ... & \tilde{x}_{1n} \\ A_2 & \tilde{x}_{21} & \tilde{x}_2 & ... & \tilde{x}_{2n} \\ : & : & : & : & : \\ A_m & \tilde{x}_{m1} & \tilde{x}_{m2} & ... & \tilde{x}_{mn} \end{array} \tag{3}$$

$$\tilde{W} = (\tilde{W}_1, \tilde{W}_2, ..., \tilde{W}_n) \tag{4}$$

where $\tilde{X}^k_{ij}$ for all i, j and $\tilde{w}_j$ i= 1, 2, , m and j = 1, 2, .., n are linguistic variables that can be described by triangular fuzzy numbers; $\tilde{X}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $(W^k_{j1}, W^k_{j2}, W^k_{j3})$.

The linear scale transformation is used to transform various criteria scales into a comparable scale. Thus, the normalized fuzzy decision matrix can be represented by $\tilde{R}$, which is an matrix $m \times n$, as shown in equation (5). The below normalization method preserves the property that ranges of normalized triangular fuzzy numbers belong to [0, 1].

$$\tilde{R} = [\tilde{r_{ij}}]_{m\times n} \tag{5}$$

where i=1, 2, , m. and j=1, 2, ,n.

$$\tilde{r_{ij}} = (\frac{a_{ij}}{c^*_j}, \frac{b_{ij}}{c^*_j}, \frac{c_{ij}}{c^*_j}); c^*_j = max_i(c_{ij}) \quad (Benefit \quad Criteria) \tag{6}$$

$$\tilde{r_{ij}} = (\frac{a_j}{c_{ij}}, \frac{a_j}{cij}, \frac{a_j}{c_{ij}}); a_j = min_i(a_{ij}) \quad (Cost \quad Criteria) \tag{7}$$

The weighted normalized fuzzy decision matrix (which is an matrix) is calculated by multiplying the weights of the evaluation criteria and the normalized fuzzy decision matrix, as shown in statement (8). This computation considers the importance of each criterion.

$$\tilde{R} = [\tilde{v_{ij}}]_{m\times n} = [\tilde{r_{ij}}]_{m\times n} \times \tilde{w_j}; i = 1, 2, ..., m \quad and \quad j = 1, 2, ..., n \tag{8}$$

The FPIS and FNIS of the alternatives (strategies in our study) are defined as shown in equations (9) and (10).

$$A^{+} = (\tilde{v}_1^{+}, \tilde{v}_2^{+}, ..., \tilde{v}_n^{+}), \quad where \quad \tilde{v}_j^{+} = max_i(v_{ij3}) \quad j = 1, 2, ..., m \quad and \quad i = 1, 2, ..., n \tag{9}$$

$$A^{-} = (\tilde{v}_1^{-}, \tilde{v}_2^{-}, ..., \tilde{v}_n^{-}), \quad where \quad \tilde{v}_j^{-} = max_i(v_{ij1}) \quad j = 1, 2, ..., m \quad and \quad i = 1, 2, ..., n \tag{10}$$

The next step is to calculate the distance of each weighted alternative from the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FPNS), as shown in equations (11) and (12).

$$d_i^{+} = \sum_{j=1}^{n} d_v(\tilde{v_{ij}}, \tilde{v}_j^{+}), i = 1, 2, ..., m \tag{11}$$

$$d_i^{-} = \sum_{j=1}^{n} d_v(\tilde{v_{ij}}, \tilde{v}_j^{-}), i = 1, 2, ..., m \tag{12}$$

where $d_v(a, b)$ is the distance measurement between the two fuzzy numbers a and b. The closeness coefficient represents the distances to the FPIS and the FNIS. The closeness coefficient CC_i of each alternative is calculated as shown is equation (13).

$$CC_i = \frac{d_i^{-}}{d_i^{-} + d_i^{+}}, i = 1, 2, ..., m \tag{13}$$

For the last step, we rank the alternatives according to the relative closeness to the ideal solution. The greater value of CC_i is, the better the alternative A_i is. The best alternative is the one with the greatest relative closeness to the ideal solution.

5 Nash equilibrium for a three-person non-constant game

In a three player game (Player 1, Player 2 and Player 3), a Nash equilibrium is a pair of strategies (A, B, C) such that A is an optimal strategy (best response) for Player 1 against B and C where B is an optimal strategy (best response) for player 2 and C is an optimal strategy for player 3 against A. In another words, Nash equilibrium is a pair of strategies, one for each player that has the property that no player can unilaterally change his/her strategy and obtain a better outcome.

Steps to find the Nash equilibrium:

Step 1 : Assume the role of one of the players - Player 1

Step 2 : Assume that your opponent (if it is a three-player game, the other players) picks a particular action or strategy.

Table 1: Strategy for Management, Academic Staff and Board of Trustee

Notation	Strategies
S1	Teaching (>70%)
S2	Research (>70%)
S3	Teaching and Research

Step 3 : Determine your best action or strategy given your opponents' actions and underline the outcome of the best strategy in the payoff matrix.

Step 4 : Repeat Steps 1 through 4 for each player of the game (for Player 2 and Player 3)

Step 5 : Any entry with all of the numbers underlined is the Nash equilibrium

Table 1 illustrates the strategies of the players, Management members (Player 1), Academic Staff members (Player 2) and Board of Trustee members (Player 3). Strategies are same for all players in the game. However, being teacher oriented means that the main aim of the university is being teaching oriented where research or teaching/research oriented is neglected. In that we have a criterion that indicate teaching mean 70% of the working hours of lecturer would be dedicated to teaching activities the same apply for research. However, research/teaching oriented means that academics spend half of their available times for teaching and other half for research activities.

In addition, we construct a game in strategic form between three players: Management, Academic Staff and Board of Trustee. Each player has three strategies, as shown in Table 1. For the next step, to construct a game, we need to calculate the outcomes of the game (i.e., we need to calculate the outcome when Player 1 chooses strategy S1, the Player 2 chooses S2 and Player 3 chooses S3). To find efficient outcomes, we assume that when the players select one of their strategies, they thought through the following criteria.

We need an expert opinion in order to determine strategies and criteria for both environment and RCS. However, rather than opting for expert opinion we created a decision making group that are expert on the field. This group consists of nine people who are; academic members, managerial members and board of trustees members from a newly founded foundation university. The chosen group also has considerable expertise and worked various state funded and foundation universities. They asked to fill a questionnaire. The scale is implanted for the purpose of transforming linguistic variables in to variables that is suggested by Zadeh (1975). For instance, age is a linguistic variable if its values are assumed to be the fuzzy variables labeled as not young‖, young‖ and very young‖ rather than the actual numbers.

Since the objectives of players are different or conflicting, importance of criteria are considered different for them. To make this difference, criteria are requested to be evaluated by separately for each player. For each criterion, membership functions are defined as Very Strong Importance‖, Strong Importance‖, Equal Importance‖, Weak

Table 2: Criteria

Notation	Criteria
C1	Research Income from Industry
C2	Ratio of International to Domestic Staff
C3	Ratio of International to Domestic Students
C4	Reputational survey (teaching)
C5	PhDs awards per academic
C6	Undergrad. admitted per academic
C7	Income per academic
C8	PhDs/undergraduate degrees awarded
C9	Reputational survey (research)
C10	Research income (scaled)
C11	Papers per research and academic staff
C12	Public research income/ total research income
C13	Citation impact (normalized average citation per paper)

Importance‖ and Very Weak Importance‖. However, these criteria have different meanings or different degrees of importance for each player. In other words, Table 2 illustrates each criterion, which are same for each player that helps to select or decide the strategies.

Each decision maker evaluates each criterion using linguistic variables in the questionnaire. The questionnaire asked decision makers to rank the order selection criteria in terms of their relative importance. In other words, each decision maker decide which criteria is most important .... Table 4, Table 5 and Table 6 illustrate decision makers' evaluation of all criteria according to linguistic variables for Player 1, Player 2 and Player 3 environment, respectively.

Table 3: Fuzzy linguistic terms and fuzzy numbers for criteria importance and strategy evaluations

Importance	Fuzzy Numbers
Very Strong Importance (VSI)	(0.844, 1.000, 1.000)
Strong Importance (SI)	(0.650, 0.844, 0.894)
Equal Importance (EI)	(0.506, 0.650, 0.844)
Weak Importance (WI)	(0.164, 0.506, 0.672)
Very Weak Importance (VWI)	(0.000, 0.000, 0.506)

Table 4: Decision makers' evaluation of criteria according to linguistic variables for Player 1

Criteria	Decision Makers								
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9
C1	VSI	VSI	SI	VSI	SI	EI	EI	WI	WI
C2	VSI	VSI	SI	VSI	SI	SI	EI	EI	WI
C3	EI	VSI	SI	VSI	SI	SI	SI	EI	SI
C4	SI	VSI	VSI	VSI	SI	VSI	VSI	SI	SI
C5	VSI	SI	SI	VSI	VSI	EI	SI	EI	EI
C6	VSI	SI	VSI	VSI	SI	EI	SI	SI	SI
C7	VSI	EI	EI	SI	EI	EI	EI	SI	EI
C8	SI	SI	SI	VSI	VSI	SI	SI	EI	WI
C9	VSI	VSI	VSI	VSI	EI	EI	VSI	SI	EI
C10	EI	VSI	SI	SI	SI	EI	EI	EI	EI
C11	SI	SI	SI	VSI	VSI	EI	SI	WI	EI
C12	SI	VSI	SI	VSI	EI	EI	EI	WI	EI
C13	SI	SI	SI	VSI	SI	VSI	SI	WI	WI

Table 7, Table 8 and 9 illustrates the correspondent fuzzy numbers from the perspective of Player 1 for each criterion.

Table 10 illustrates the weights of the criteria in TFN form.

Now, we are on the way to analyze strategies according to the stated criteria. In this step, strategies are compared with competitor player strategies reciprocally. Table 11 illustrates the evaluation of Player 1' strategies according to C1 in the case of the other players' first strategy.

The evaluation of both Player 1's, Player 2's and Player 3's strategies according to each criterion done separately. In other words, methodology is applied for all combinations of players' strategies. Table 11 is only an example for this evaluation.

Table 12, Table 13 and Table 14 illustrate (Player 1's strategies) fuzzy decision matrix of all criteria (S1 Case). Again, the methodology is applied for all combinations.

Table 15 illustrates Player 1's ideal solutions for S1 case includes positive and negative effect and the matrix is same for all players in the game.

Table 5: Decision makers' evaluation of criteria according to linguistic variables for Player 2

Criteria	Decision Makers								
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9
C1	EI	EI	EI	SI	EI	EI	EI	VSI	VSI
C2	SI	EI	EI	EI	EI	EI	WI	EI	EI
C3	SI	EI	WI	EI	SI	EI	WI	EI	SI
C4	SI	VSI	VSI	VSI	SI	VSI	WI	EI	VSI
C5	VSI	VSI	VSI	VSI	VSI	VWI	VSI	SI	VSI
C6	VSI	VSI	SI	SI	SI	SI	SI	EI	VSI
C7	VSI	VSI	SI	VSI	VSI	VSI	SI	EI	VSI
C8	EI	VSI	EI	EI	SI	SI	SI	VSI	VSI
C9	SI	VSI	VSI	VSI	SI	EI	VSI	SI	VSI
C10	VSI	SI	VSI	VSI	VSI	EI	SI	SI	VSI
C11	SI	VSI	VSI	SI	VSI	EI	VSI	SI	VSI
C12	EI	EI	EI	SI	SI	EI	EI	SI	SI
C13	VSI	VSI	VSI	VSI	SI	VSI	VSI	SI	VSI

Table 6: Decision makers' evaluation of criteria according to linguistic variables for Player 3

Criteria	Decision Makers								
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9
C1	VSI	SI	VSI	VSI	SI	SI	EI	SI	SI
C2	EI	SI	EI	VSI	SI	VSI	EI	EI	WI
C3	EI	SI	SI	VSI	EI	VSI	SI	EI	SI
C4	SI	VSI	SI	VSI	SI	SI	VSI	VSI	VSI
C5	SI	VSI	EI	VSI	SI	SI	EI	EI	EI
C6	SI	VSI	SI	WI	EI	SI	VSI	EI	WI
C7	EI	SI	SI	SI	SI	EI	SI	SI	SI
C8	EI	VSI	EI	VSI	SI	VSI	SI	WI	EI
C9	SI	VSI	VSI	VSI	VSI	SI	WI	SI	VSI
C10	SI	SI	SI	VSI	VSI	SI	EI	SI	SI
C11	SI	VSI	SI	VSI	SI	VSI	WI	EI	SI
C12	VSI	SI	VSI	SI	SI	VSI	EI	EI	EI
C13	SI	VSI	EI	VSI	VSI	VSI	WI	WI	EI

Table 7: The Correspondent fuzzy numbers used in the criteria evaluation for Player1

	C1	C2	C3	C4	C5
DM1	(0.844,1.000,1.000)	(0.844,1.000,1.000)	(0.506,0.672,0.844)	(0.672,0.844,0.844)	(0.844,1.000,1.000)
DM2	(0.844,1.000,1.000)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)	(0.672, 0.844, 0.844)
DM3	(0.672,0.844,0.894)	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.844, 1.000, 1.000)	(0.672, 0.844, 0.844)
DM4	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)
DM5	(0.672, 0.844, 0.894)	(0.672, 0.844, 0.894)	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)
DM6	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.894)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)	(0.506, 0.672, 0.844)
DM7	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)	(0.672, 0.844, 0.844)
DM8	(0.164, 0.506, 0.672)	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)
DM9	(0.164, 0.506, 0.672)	(0.164, 0.506, 0.672)	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)

Table 8: The Correspondent fuzzy numbers used in the criteria evaluation for Player1

	C6	C7	C8	C9
DM1	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)
DM2	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)
DM3	(0.844, 1.000, 1.000)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)
DM4	(0.844, 1.000, 1.000)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)
DM5	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)	(0.844, 1.000, 1.000)	(0.506, 0.672, 0.844)
DM6	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)
DM7	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)
DM8	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)
DM9	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)	(0.164, 0.506, 0.672)	(0.506, 0.672, 0.844)

Table 9: The Correspondent fuzzy numbers used in the criteria evaluation for Player1

	C10	C11	C12	C13
DM1	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)
DM2	(0.844, 1.000, 1.000)	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)	(0.672, 0.844, 0.844)
DM3	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)	(0.672, 0.844, 0.844)
DM4	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)	(0.844, 1.000, 1.000)
DM5	(0.672, 0.844, 0.844)	(0.844, 1.000, 1.000)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)
DM6	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.844, 1.000, 1.000)
DM7	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)	(0.506, 0.672, 0.844)	(0.672, 0.844, 0.844)
DM8	(0.506, 0.672, 0.844)	(0.164, 0.506, 0.672)	(0.164, 0.506, 0.672)	(0.164, 0.506, 0.672)
DM9	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.506, 0.672, 0.844)	(0.164, 0.506, 0.672)

Table 10: Criteria fuzzy weight matrix for all players

Criteria	Management			Academic Staff			Board of Trastee		
	a	b	c	a	b	c	a	b	c
C1	0.1644	0.7827	1.0000	0.5056	0.7642	1.0000	0.5056	0.8772	1.0000
C2	0.1644	0.8012	1.0000	0.1644	0.6728	0.8939	0.1644	0.7648	1.0000
C3	0.5056	0.8216	1.0000	0.1644	0.6926	0.8939	0.5056	0.8216	1.0000
C4	0.6722	0.9309	1.0000	0.1644	0.8741	1.0000	0.6722	0.9309	1.0000
C5	0.5056	0.8389	1.0000	0.0000	0.8716	1.0000	0.5056	0.8025	1.0000
C6	0.5056	0.8772	1.0000	0.5056	0.8772	1.0000	0.1644	0.7654	1.0000
C7	0.5056	0.7469	1.0000	0.5056	0.9117	1.0000	0.5056	0.8062	0.8939
C8	0.1644	0.8222	1.0000	0.5056	0.8389	1.0000	0.1644	0.8012	1.0000
C9	0.5056	0.8735	1.0000	0.5056	0.9117	1.0000	0.1644	0.8932	1.0000
C10	0.5056	0.7660	1.0000	0.5056	0.9117	1.0000	0.5056	0.8599	1.0000
C11	0.1644	0.8031	1.0000	0.5056	0.9117	1.0000	0.1644	0.8395	1.0000
C12	0.1644	0.7648	1.0000	0.5056	0.7488	0.8939	0.5056	0.8389	1.0000
C13	0.1644	0.8037	1.0000	0.6722	0.9654	1.0000	0.1644	0.8000	1.0000

Table 11: Player 1's evaluation according to C1 with linguistic variables (S1 Case)

Criteria C1	Linguistic variables			Correspondent fuzzy Numbers		
	S1	S2	S3	S1	S2	S3
DM1	WI	SI	SI	(0.16, 0.51, 0.67)	(0.67, 0.84, 0.89)	(0.67, 0.84, 0.89)
DM2	VSI	VSI	VSI	(0.84, 1.00, 1.00)	(0.84, 1.00, 1.00)	(0.84, 1.00, 1.00)
DM3	EI	VSI	VSI	(0.51, 0.67, 0.84)	(0.84, 1.00, 1.00)	(0.84, 1.00, 1.00)
DM4	SI	VSI	SI	(0.67, 0.84, 0.89)	(0.84, 1.00, 1.00)	(0.67, 0.84, 0.89)
DM5	EI	EI	EI	(0.51, 0.67, 0.84)	(0.51, 0.67, 0.84)	(0.51, 0.67, 0.84)
DM6	SI	EI	SI	(0.67, 0.84, 0.89)	(0.51, 0.67, 0.84)	(0.67, 0.84, 0.89)
DM7	VWI	VSI	EI	(0.00, 0.00, 0.51)	(0.84, 1.00, 1.00)	(0.51, 0.67, 0.84)
DM8	EI	EI	SI	(0.51, 0.67, 0.84)	(0.51, 0.67, 0.84)	(0.67, 0.84, 0.89)
DM9	WI	EI	WI	(0.16, 0.51, 0.67)	(0.51, 0.67, 0.84)	(0.16, 0.51, 0.67)

Table 12: Player 1's strategies fuzzy decision matrix for C1, C2, C3, C4 and C5 (S1 Case)

	C1			C2			C3			C4			C5		
S11	0.00	0.64	1.00	0.16	0.75	1.00	0.51	0.80	1.00	0.67	0.91	1.00	0.16	0.76	1.00
S21	0.51	0.84	0.89	0.16	0.73	1.00	0.16	0.69	1.00	0.16	0.75	1.00	0.16	0.80	1.00
S31	0.16	0.80	1.00	0.16	0.77	1.00	0.16	0.75	0.89	0.51	0.88	1.00	0.16	0.75	0.89

Table 13: Player 1's strategies fuzzy decision matrix for C6, C7, C8, C9 and C10 (S1 Case)

	C6			C7			C8			C9			C10		
S11	0.51	0.86	1.00	0.51	0.84	1.00	0.16	0.76	1.00	0.16	0.67	1.00	0.00	0.60	1.00
S21	0.00	0.66	0.89	0.51	0.82	1.00	0.16	0.71	1.00	0.16	0.84	1.00	0.51	0.84	1.00
S31	0.16	0.77	1.00	0.51	0.82	1.00	0.51	0.75	1.00	0.51	0.84	1.00	0.16	0.80	1.00

Table 14: Player 1's strategies fuzzy decision matrix for C11, C12, and C13 (S1 Case)

	C11			C12			C13		
S11	0.16	0.76	1.00	0.00	0.62	1.00	0.00	0.60	1.00
S21	0.51	0.88	1.00	0.16	0.82	1.00	0.16	0.86	1.00
S31	0.51	0.84	1.00	0.51	0.84	1.00	0.16	0.84	1.00

Table 15: Player 1' ideal solutions (S1 Case)

	C1	C2	C3	C4	.	C12	C13
Positive	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	.	(1, 1, 1)	(1, 1, 1)
Negative	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)		(0, 0, 0)	(0, 0, 0)

Table 16: The distances from FPIS Player 1' ideal solutions

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	Sum
S11	0,65	0,61	0,47	0,33	0,57	0,45	0,48	0,57	0,58	0,66	0,60	0,65	0,65	7,27
S21	0,57	0,61	0,59	0,54	0,56	0,63	0,48	0,58	0,55	0,48	0,56	0,60	0,59	7,34
S31	0,60	0,60	0,58	0,40	0,57	0,56	0,48	0,48	0,46	0,57	0,56	0,57	0,59	7,04

Table 17: The distances from FNIS Player 1' ideal solutions

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	Sum
S11	0,64	0,67	0,71	0,80	0,69	0,74	0,70	0,68	0,67	0,63	0,68	0,64	0,64	8,90
S21	0,64	0,67	0,67	0,71	0,70	0,61	0,69	0,67	0,72	0,70	0,71	0,68	0,70	8,87
S31	0,68	0,68	0,63	0,77	0,63	0,70	0,69	0,69	0,73	0,68	0,70	0,69	0,70	8,97

Table 18: Closeness Coefficient for Player 2 (Player 1: Teaching, Player 3: All Strategies)

Player 1 Teaching							
		Player 3					
		Teaching		Research		Teaching & Research	
		IC	Rank	IC	Rank	IC	Rank
Player 2	Teaching	0,5955	2	0,5955	3	0,5955	3
	Research	0,6475	1	0,6475	2	0,6475	2
	Teaching & Research	0,5955	2	0,6515	1	0,6769	1

Table 19: Closeness Coefficient for Player 2 (Player 1: Research, Player 3: All Strategies)

Player 1 Research							
	Player 3						
		Teaching		Research		Teaching & Research	
		IC	Rank	IC	Rank	IC	Rank
Player 2	Teaching	0,5955	2	0,5955	3	0,5955	3
	Research	0,6475	1	0,7099	1	0,6475	1
	Teaching & Research	0,6475	1	0,6475	2	0,6230	2

Table 20: Closeness Coefficient for Player 2 (Player 1: Teaching & Research, Player 3: All Strategies)

Player 1 Teaching and Research	a						
		Player 3					
		Teaching		Research		Teaching & Research	
		IC	Rank	IC	Rank	IC	Rank
Player 2	Teaching	0,5723	2	0,5741	3	0,5955	2
	Research	0,6475	1	0,6230	2	0,6475	1
	Teaching & Research	0,6475	2	0,6475	1	0,6475	1

Table 21: Payoff Matrix: Player 1 Chooses Strategy Teaching

		Player 3		
		Teaching	Research	Teaching & Research
	Teaching	(0.5955, 0.5781, 0.5362)	(0.5955, 0.5781, 0.5362)	(0.5955, 0.6302, 0.5362)
Player 2	Research	(0.5955, 0.5781, 0.5663)	(0.6515, 0.5927, 0.6446)	(0.6769, 0.7523, 0.6446)
	Teaching & Research	(0.6475, 0.5927, 0.6165)	(0.6475, 0.5927, 0.6165)	(0.6475, 0.7523, 0.6165)

Table 22: Payoff Matrix: Player 1 Chooses Strategy Research

		Player 3		
		Teaching	Research	Teaching & Research
	Teaching	(0.5955, 0.6302, 0.5362)	(0.5955, 0.5781, 0.5663)	(0.5955, 0.5781, 0.5362)
Player 2	Research	(0.6475, 0.6302, 0.6165)	(0.7099, 0.6003, 0.6165)	(0.6475, 0.5781, 0.6446)
	Teaching & Research	(0.6475, 0.8269, 0.6165)	(0.6475, 0.6003, 0.6165)	(0.6230, 0.5927, 0.6165)

Table 23: Payoff Matrix: Player 1 Chooses Strategy Teaching and Research

		Player 3		
		Teaching	Research	Teaching & Research
	Teaching	(0.5723, 0.5781, 0.5362)	(0.5741, 0.5781, 0.5663)	(0.5955, 0.5781, 0.5362)
Player 2	Research	(0.6475, 0.5927, 0.6165)	(0.6230, 0.5927, 0.6446)	(0.6475, 0.5927, 0.6446)
	Teaching & Research	(0.6475, 0.5927, 0.6165)	(0.6475, 0.5781, 0.6165)	(0.6475, 0.5927, 0.6165)

Table 24: Nash Equilibrium Strategies: Results

Player 1	Player 2	Player 3
Teaching	Research	Teaching & Research
Research	Research	Teaching
Teaching & Research	Research	Teaching
Teaching & Research	Research	Teaching & Research
Teaching & Research	Teaching & Research	Teaching
Teaching & Research	Teaching & Research	Teaching & Research

6 Discussion and Conclusion

Out of three different alternatives in most cases the best option for players are either opting for being research or research/teaching-oriented. Different options are identified for each player and most of the cases equilibrium are reached and consequently the players made their strategies according to knowledge that they have. As a result, in many cases maximum benefits are achieved when players are chosen to be research or research/teaching oriented. It should be recognized that the players reached their decision through the information that readily available to them. It is also interesting to see during the game academics opted mostly for being teaching/research oriented whereas management have chosen research orientation.

Arguably, and perhaps not surprisingly board of trustees' players often supported both teaching and teaching/research orientations. Out of eighteen options, in different circumstances and available information, players five times opted for research, four times for teaching oriented and nine times teaching/ research orientation. One fundamental conceptual issue in regard to such decision is that the "teaching versus research" decision is typically not an "either/or" but more a matter of selecting a point on a continuum, in response to the competitive environment and the resources (especially faculty but also labs and libraries) available. The standard Carnegie classification of university types illustrates this point. However, given the available information, competitive environment, and limited resources where an independent school solely relies on tuition fees- players may be impelled to be very cautious. It may also be that most players conclude that the university should conduct both activities simultaneously. The standard rationale is that teaching activities are important for short and medium term survival, but should be informed by cutting edge research, for the benefit of student learning. However, unless academic and other resources suffice to sustain both activities, a tuition-dependent university could end up losing its reputation and might suffer a substantial decrease in student enrollment, as a result of such an effort to manage beyond its means. This may literally make survival impossible. Therefore, each player within the game strives to maximize his or her benefits with the limited knowledge and resources available. Further, in practice, environments are usually competitive rather than neutral. Three points become particularly salient: information, resource availability and the competitive landscape. These significantly impact each player's decision. The fuzzy TOPSIS method clearly indicates the best option available for all players. In conclusion, the fuzzy TOPSIS method makes it evident that even when three main outcome categories are used for the purposes of simplicity, with three major sets of players, and the competitive environment held neutral, in 50% of the results, these players collectively chose a combination of teaching and research. This outcome is most notable in the case of the first player, with 66% of choices falling into this category. Further research might generate a model that includes a range of teaching and research continuum points, and allows for the identification of more fine-grained choices, with a dynamic rather than constant environment.

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